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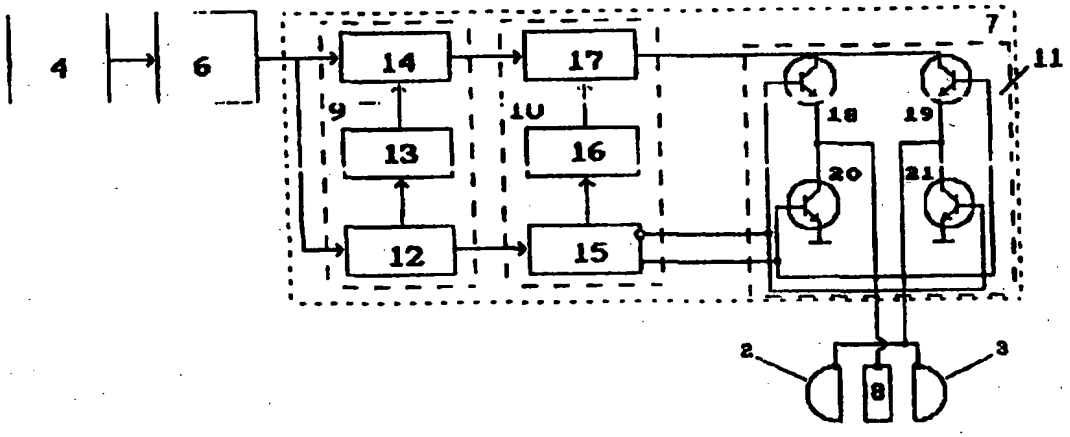

(57) Abstract

The present invention is designed for electrostimulation of, preferably, gastrointestinal tract. Each of proposed embodiments of the present invention comprises an olive-like or ovate-cylindrical body member (1) in which at least a part of opposed hemispheres is made conducting and forms a pair of electrodes (2, 3), as well as a pulse generator (6) and an electric power supply source (4) disposed inside said body member (1). In its first embodiment, the present invention additionally comprises means (7) for cyclically reversing polarity of pulses on said electrodes (2, 3). In its second embodiment, the present invention additionally comprises an electrode (8) disposed on the body member (1) between said electrodes (2, 3). In so doing, said additional electrode (8) is connected to one electrical lead of the pulse generator (6) whereas the above-mentioned electrodes (2, 3) are connected to another lead of the pulse generator (6). In its third embodiment, the present invention additionally comprises an electrode (8) and means (7) for cyclically reversing polarity of pulses on said electrodes (2, 3, 8), wherein said additional electrode (8) is disposed on the body member (1) between the above-mentioned electrodes (2, 3) being disposed on said hemispheres such that said additional electrode (8) is connected to one electrical lead of the pulse generator (6) whereas the above-mentioned electrodes (2, 3) are connected to another lead of the pulse generator (6). Electrostimulation efficiency of the device is independent upon opposite preferential orientations of its body member within a given visceral organ of a human being or animal.

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BIOLOGICAL ELECTROSTIMULATOR OF VISCERA

BACKGROUND OF THE INVENTION

I. FIELD OF THE INVENTION

The present invention relates generally to medicine and more particularly to electrotherapy and can be used for electrically stimulating viscera, preferably gastrointestinal tract.

II. DESCRIPTION OF THE PRIOR ART

There has been known a problem for recovering depressed functions of viscera. Electrical stimulation is one of different ways of resolving this problem and has been used for more than a hundred of years.

Known in the art is a gastroenterostimulator "Endoton-1" described in the brochure "Gastroenterostimulator "Endoton-1" by A. I. Korobkov, TsBNTI medprom, Moscow, 1981, pp. 1-16 [1], which is adapted for the promotion of motor activity of gastrointestinal tract for therapeutic and prophylactic purposes in acute and chronic hypodynamia and adynamia of intestine. An apparatus disclosed comprises a generator of square electric pulses generated under continuous or discontinuous conditions, one type of a passive electrode in the form of a 40 x 100 mm plate which is applied to the patient body, and three types of active electrodes: a gastric electrode-probe in the form of a flexible tube with an olive-like conducting end (a so-called olive-end probe), rectal and anal electrodes. With the help of said apparatus one may perform transcutaneous, transduodenal and transrectal electrical stimulation of gastrointestinal tract as well as electrical stimulation of anal constrictor. Main disadvantages of that

design reside in its limited use for the patients, especially at the stage of inserting and removing active electrodes.

There has been also known an electrostimulator adapted to be used for treating gastrointestinal tract, which is made in the form of a streamline-shaped swallowed capsule having inside a pulse generator and an electric power supply source therefor. The electrodes of this electrostimulator are made in the form of two electrically insulated parts of said capsule. Electric pulses affecting intestine wall cause the response to the stimulus in the form of peristalsis wave which advances the electrostimulator along with the contents of intestine to distal regions thereof. In so doing, the electrostimulator, in its way through intestine, presumably electrically stimulates in local manner all the departments of intestine. At the same time, the use of said electrostimulator shows that the efficiency of electrostimulation is not reliable: in a number of cases of passing said electrostimulator through intestine the effect of electrical stimulation may be reduced or even absent in full. It is determined that such a phenomenon is due to equally probable random orientations of the electrostimulator with respect to the intestine walls. Moreover, a prolonged presence of the prior art electrostimulator in the aggressive medium of gastrointestinal tract (up to 48 hours and more) results in a considerable corrosion of electrodes up to their degradation and the capsule seal failure. Hence, there is a danger of corrosion product toxic effect (see "Gastrointestinal Tract Electrostimulator" described by Pekarsky V. V., Dambaev G. Ts. et al. in USSR Inventor's Certificate No. 936931, Int. Cl. A 61 N 1/36, June 23, 1982, Bulletin No. 23). [2]

The closest prior art in respect of the result obtainable has been described by Pekarsky V. V., Agafonnikov V. F., Dambaev G. Ts., Glushchuk S. F., Martusevich A. G. in USSR Inventor's Certificate No.

1223922, Int. Cl. A 61 N 1/36, April 15, 1986, Bulletin No. 14, which is entitled "Gastrointestinal Tract Electrostimulator"). [3] This prior art device the essential features of which are disclosed above and in [2] is characterized in that, in order to provide for the possibility of administering medicinal agents in the region of electrostimulation, one of the electrodes is fitted with a pipe connection in the form of a hollow cylinder having openings on the lateral face to be connected to a drainage tube. Such an electrostimulator is adapted to be used with the drainage tube which additionally makes it possible that the electrostimulator be somewhat spatially-oriented. At the same time, such an electrostimulator may be used only with a restricted part of gastrointestinal tract (stomach, duodenum or large intestine). Moreover, it suffers from an insufficient corrosion resistance.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a self-contained biological electrostimulator of viscera which possesses a more stable (more reliable) electrostimulation efficiency and, hence, treatment efficiency as well as an improved corrosion-resistance and, hence, an eliminated risk of adverse side effects caused by its application.

In accordance with the present object and a first embodiment of the present invention, a biological electrostimulator of viscera, as the prior art device, comprises an olive-like or ovate-cylindrical body member in which at least a part of two opposite hemispheres thereof is made conducting and forms electrodes, as well as a pulse generator and an electric power supply source which are located inside said body member. As distinct from the prior art device, the electrostimulator according to the invention

additionally comprises means for cyclically reversing polarity of pulses on said electrodes.

Owing to an oblong shape of the body member, the electrostimulator takes in intestine mostly a longitudinal position and, as compared to the prior art device, the electrostimulator according to the invention acts, regardless of two possible opposite such orientations, on intestine walls with current pulses, wherein half of them has current direction coincident with that of peristalsis, that is, electrostimulation efficiency is improved. Moreover, cyclical reversal of pulse polarity on the electrodes diminishes polarisation effect of these electrodes and, hence, significantly reduces the rate of electrochemical corrosion.

In accordance with a second embodiment of the present invention, a biological electrostimulator comprises those features common with the prior art device which are recited in the first embodiment, but differs from the prior art device in that it additionally comprises an electrode disposed on the body member between the above-mentioned electrodes, wherein said additional electrode is connected to one electrical lead of the pulse generator whereas the above-mentioned electrodes being common with the prior art device are connected to another lead of the pulse generator. Such a design also brings down the dependence of electrostimulation efficiency upon two preferential orientations of the electrostimulator body member and, hence, improves the efficiency thereof. Improvement of electrostimulation efficiency results in a decrease in the electrostimulator residence time inside the body (in particular, in intestine) and, hence, a decrease in a level of corrosion with respect to the electrodes.

In accordance with a third embodiment of the present invention, a biological electrostimulator also comprises those features common with the prior art device which are recited in the first embodiment, but differs

from the prior art device in that it additionally comprises means for cyclically reversing polarity of pulses on the above-mentioned electrodes and an additional electrode disposed on the body member between the above-mentioned electrodes being common with the prior art device, wherein said additional electrode is connected to one electrical lead of the pulse generator whereas the above-mentioned electrodes being common with the prior art device are connected to another lead of the pulse generator. Such a design allows a combination of lowering the dependence of electrostimulation efficiency upon two equally probable longitudinal orientations of the electrostimulator body member and a simultaneous decrease in the rate of electrochemical corrosion at the expense of diminishing the polarisation effect of the electrodes.

In the preferred embodiment of the present invention, it is expedient that said means for cyclically reversing polarity of pulses on said electrodes be made in the form of at least one pulse packet shaper and a multiplexing switch controlling said shaper. It has been determined experimentally that the most efficient electrostimulation could be attained with pulse packets following at regular intervals. At the expense of switching each successive pulse packet on the electrodes in polarity opposite to that of the preceding packet and of a random character of orientation of the electrostimulator body member in each point of location, there is formation, in the course of time, of a series of pulse packets having polarity which is more efficient for electrically stimulating a certain visceral organ.

It is preferred that an additional electrode be made ring-shaped, transversely encompassing said olive-like or ovate-cylindrical body member. Such an embodiment of the additional electrode makes it axially symmetric in the longitudinal direction of the body member and, hence,

enables a reliable electrical action in any radial (with respect to the electrostimulator body member) direction.

It is also preferred that said electrodes on hemispheres of said olive-like or ovate-cylindrical body member of the electrostimulator be provided equidistant from said additional electrode. This enables a more identity of conditions of electrical action on tissues of a certain visceral organ of each pair of electrodes formed from the above-mentioned electrodes and an additional electrode. In so doing, it seems worthwhile that the above-mentioned electrodes be provided identical on hemispherical ends of the electrostimulator body member. In this way, a degree of identity of conditions for internal electrical action on tissues of a certain visceral organ is optimised just in the very part in which these conditions are determined by means of the electrostimulator.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described in greater detail with reference to specific embodiments thereof and to accompanying drawings, in which:

FIGURE 1 illustrates a first preferred embodiment of the electrostimulator according to the invention;

FIGURE 2 is an electric schematic, showing said first preferred embodiment of the electrostimulator according to the invention;

FIGURE 3 illustrates a second preferred embodiment of the electrostimulator according to the invention; in so doing, a third embodiment of the present invention does not require a separate drawing and is also shown in FIGURE 3;

FIGURE 4 is an electric schematic, showing said second preferred embodiment of the electrostimulator according to the invention, wherein the electrodes are presented in the form and arrangement of FIGURE 3;

FIGURE 5 is an electric schematic, showing said third embodiment of the electrostimulator according to the invention, wherein the electrodes are presented in the form and arrangement of FIGURE 3.

Throughout the drawings, like reference numerals should be understood to refer to like components.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

According to each embodiment of the present invention, an electrostimulator in its preferred accomplishment comprises the following common essential features: an ovate-cylindrical body member **1** (FIGURES **1**, 3) which is made hermetically sealed, hemispherical ends of the body member **1** which are made conducting and form a pair of electrodes **2**, **3**. Disposed inside said body member **1** are an electric power supply source **4** (FIGURES **2**, **4**, **5**) in the form of in series connected galvanic cells **5** (FIGURES **1**, **3**) and a pulse generator **6** connected thereto.

In its first embodiment, the present invention, apart from those common features disclosed above, additionally comprises means **7** for cyclically reversing polarity of pulses on said electrodes **2**, **3** (FIGURE **2**). In this case, said means are provided in a common hybrid-integrated design with the pulse generator **6** and disposed within the body member **1** (FIGURE **1**).

In its second embodiment as depicted in FIGURES 3, **4**, the present invention, apart from those common features disclosed above,

additionally comprises an electrode **8** disposed on the body member **1** between said electrodes **2**, **3** and made ring-shaped, transversely encompassing said body member **1** of the electrostimulator (FIGURE 3). In so doing, as depicted in FIGURE **4**, said additional electrode **8** is connected to one electrical lead of the pulse generator **6** whereas the above-mentioned electrodes **2**, **3** are connected to another lead of the pulse generator **6**.

In its third embodiment, the present invention, apart from those common features disclosed above, additionally comprises an electrode **8** made and disposed as depicted above with reference to FIGURE 3, and means **7** for cyclically reversing polarity of pulses on said electrodes **2**, **3**, **8**, wherein the above-mentioned electrodes **2**, **3** being electrically closed.

In the preferred embodiment of the present invention, said means **7** for cyclically reversing polarity of pulses of the generator **6** are made in the form of in series connected pulse packet shapers **9** and **10** and a multiplexing switch **11**. A pulse packet shaper **9** is made in the form of in series connected a pulse counter **12** and a combinatorial circuit **13** and connected with its control input to an output of the last electronic key **14**. In so doing, a high order output of the counter **12** and an output of electronic key **14** form outputs of the pulse packet shaper **9**. A pulse packet shaper **10** is made similar to the shaper **9** and in the form of in series connected a pulse counter **15** and a combinatorial circuit **16** as well as electronic key **17** connected with its control input to an output of the combinatorial circuit **16**. The counter **15** includes an additional, that is to say not connected to the combinatorial circuit **16**, high order with its direct and inverted outputs being connected to control inputs of the multiplexing switch **11**. The multiplexing switch **11** comprises four transistors **18**, **19**, **20**, **21** bridge connected to each other. A signal input of the multiplexing

switch **11** is formed by the connection of collectors of the transistors **18** and **19** and the connection of emitters of the transistors **20** and **21**, whereas its output is formed by the connection of the emitter and collector of the transistors **18** and **20** and the transistors **19** and **21**. The output of the multiplexing switch **11** is connected to the electrodes **2**, **3** (FIGURE **2**) or to a pair of electrodes formed by the electrode **8** and electrically closed electrodes **2**, **3**. Control inputs of the multiplexing switch **11** are formed by in pairs connected bases of the transistors **18** and **21** and the transistors **19** and **20** and connected to said inverted and direct outputs, respectively, of the counter **15**.

All embodiments of the present invention are equally applicable for operation in the following manner. Under voltage supplied from the power supply source **4**, the generator **6** generates pulses of a predetermined duration (for example, 5 milliseconds) and a predetermined repetition frequency (for example, 40 Hertz). These pulses are delivered to the electrodes **2**, **3** (the first embodiment of the present invention) or to a pair of electrodes formed by electrically interconnected electrodes **2**, **3** and the electrode **8** (the second and third embodiments of the present invention). Via said electrodes, pulses affect surrounding tissues by means of electric current pulse which produces the response to the stimulus caused by electrostimulation. In view of a longitudinal axial symmetry of the body member **1**, a mutual identity in form and dimensions of the electrodes **2** and **3**, a ring-shaped format of the additional electrode **8** and because of the fact that the electrodes **2** and **3** are equally spaced from the electrode **8**, electric current pulses excited by the electrostimulator in surrounding tissues are the same at each inter-electrode interval and around the entire circumference of the body member **1**. Differences are possible only due to

different conditions of the contact between the electrodes **2**, **3**, **8** and visceral tissues.

In accordance with the first and third embodiments of the present invention, pulses from the generator **6** are passed to the electrodes **2** and **3** or the electrodes **2**, **3** and **8**, respectively, with cyclical reversal of pulse polarity carried out by the means **7** responsible for performing this function. Advantageously, this function will be performed following receipt from a sequence of pulses of the generator **6** of those pulse packets which have a predetermined number, for example, 16 pulses per packet, by means of the shapers **9** and **10** and the multiplexing switch **11** which controls transmission of these pulse packets in opposite polarity to the electrodes **2**, **3** (FIGURES **1**, **2**) or the electrodes **2**, **3**, **8** (FIGURES **3**, **4**, **5**).

In a particular embodiment disclosed with respect to the shapers **9**, **10** which is not the only possible embodiment, pulses from the generator **6** are passed to a signal input of the electronic key **14** and to a count input of the counter **12** where they are used as count pulses. The counter **12** along with the combinatorial circuit **13** being connected to the output thereof, forms a control pulse which duration is equal to that of a sequence of a predetermined number (for example 16) of pulses of the generator **6**. Under the action of this control pulse, the electronic key **14** switches to its input a specified predetermined number of pulses of the generator **6**, that is to say a pulse packet is formed. In so doing, conversion coefficient of the counter **12** defines a repetition period of this pulse packet.

The pulse packet shaper **10** operates in analogous manner to that of the shaper **9** and affords formation of a group of pulse packets formed by the shaper **9**, that is to say a packet of packets is formed. In this case, input

of the counter **15** receives pulses each fixing the formation of a separate pulse packet at the output of the shaper **9**.

An additional high order of the counter **15** which is not connected to the combinatorial circuit **16**, with its direct and inverted outputs controls the multiplexing switch **11**. At said outputs of the counter **15**, pulses having a voltage of logic 1 and pauses having a voltage of logic 0 are time-reversed, wherein pulse duration and pause duration are equal to that of a specified group of pulse packets. When a voltage of logic 1 is applied to bases of the transistors **18**, **21** and a voltage of logic 0 is applied to bases of the transistors **19**, **20**, then the electrode **2** (FIGURE 2) or the electrode **8** (FIGURE 5) receives, via an on transistor **18**, a group of pulse packets having a positive polarity with respect to the electrode **3** (FIGURE 2) or with respect to the electrodes **2** and **3** (FIGURE 5) connected via an on transistor **21** with a common wire. When a voltage of logic 0 is applied to bases of the transistors **18**, **21** and a voltage of logic 1 is applied to bases of the transistors **19**, **20**, then the electrode **3** (FIGURE 2) or the electrode **2** and **3** (FIGURE 5) receives, via an on transistor **19**, a group of pulse packets having a positive polarity with respect to the electrode **2** (FIGURE 2) or with respect to the electrode **8** (FIGURE 5) connected via an on transistor **20** with a common wire. In such manner, reversal of polarity of electric pulses on said electrodes take place.

The above example of implementing the means **7** for cyclically reversing pulse polarity on said electrodes enables accomplishment of a temporary sequence of groups of pulse packets with any predetermined number of pulses in the packet having a predetermined repetition period of packets and a predetermined number of packets in any group of packets. It follows that cyclical reversal of pulse polarity may be performed taking

into account a temporary character of physiological activity of the response of viscera to electrostimulation. The application of one pulse packet shaper **9** or **10** is minimum sufficient to rise electrostimulation efficiency and to lower electrochemical corrosion of electrodes.

Other designs of the pulse packet shapers **9**, **10** and the multiplexing switch **11** as well as of the means **7** for cyclically reversing polarity of pulses on the electrodes are contemplated within the scope of the embodiments disclosed.

INDUSTRIAL APPLICABILITY

The present invention can be used for treating functional disorders of relatively inaccessible viscera of the human or animal body by means of electrical stimulation. In a preferred embodiment of the present invention, i.e. that adapted for gastrointestinal tract electrical stimulation, the electrostimulator according to the present invention is characterized by the combination of an improved electrostimulation efficiency under conditions of its free movement which is due to a reduced dependence upon various equally possible orientations of its body member with respect to the direction of peristalsis wave of intestine wall, and a reduced electrochemical corrosion due to a decrease in the electrode polarizability at the expense of cyclical reversal of pulse polarity thereon and/or the above-mentioned improved electrostimulation efficiency. These properties of the electrostimulator affords expansion of the field of application thereof. The electrostimulator may be used both when being inserted and when being immovably located in the predetermined region of a relatively inaccessible organ (prostate, uterus, appendages, etc.). To this end, the electrostimulator may be fitted with a flexible carrier made rigid enough to be used for pushing and returnable movement of the electrostimulator.

The results of a representative number of experiments with the proposed electrostimulator show that a number of cases of inefficient application has been reduced at least half of that occurred with the prior art device [2].

Although the present invention has been described with reference to preferred embodiments, the invention is not limited to the details thereof, and various changes and modifications obvious to one skilled in the art to which the invention pertains are deemed to be within the spirit, scope and contemplation of the invention as further defined in the appended claims.

WHAT IS CLAIMED IS:

1. A biological electrostimulator of viscera comprising an olive-like or ovate-cylindrical body member **1** in which at least a part of two opposite hemispheres thereof is made conducting and forms electrodes **2**, **3**; a pulse generator **6**; and an electric power supply source **4** which are located inside said body member **characterized in that** it additionally comprises means **7** for cyclically reversing polarity of pulses on said electrodes **2**, **3**, wherein electrostimulation efficiency of the device is independent upon opposite orientations of its body member within a given visceral organ.

2. An electrostimulator as claimed in claim **1** **characterized in that** said means **7** for cyclically reversing polarity of pulses on said electrodes **2**, **3** are made in the form of at least one pulse packet shaper **9** and a multiplexing switch **11** controlling said shaper.

3. A biological electrostimulator of viscera comprising an olive-like or ovate-cylindrical body member **1** in which at least a part of two opposite hemispheres thereof is made conducting and forms electrodes **2**, **3**; a pulse generator **6**; and an electric power supply source **4** which are located inside said body member **characterized in that** it additionally comprises an electrode **8** disposed on the body member **1** between said electrodes **2**, **3**, wherein said additional electrode **8** is connected to one electrical lead of the pulse generator **6** whereas the electrodes **2**, **3** are connected to another lead of the pulse generator **6**, and electrostimulation

efficiency of the device is independent upon opposite orientations of its body member within a given visceral organ.

4. An electrostimulator as claimed in claim 3 **characterized in that** said additional electrode 8 is made ring-shaped, transversely encompassing said olive-like or ovate-cylindrical body member 1.

5. An electrostimulator as claimed in claim 3 **characterized in that** said electrodes 2 , 3 on hemispheres of said olive-like or ovate-cylindrical body member 1 are provided equidistant from said additional electrode 8.

6. An electrostimulator as claimed in claim 4 **characterized in that** said electrodes 2 , 3 on hemispheres of said olive-like or ovate-cylindrical body member 1 are provided equidistant from said additional electrode 8.

7. A biological electrostimulator of viscera comprising an olive-like or ovate-cylindrical body member 1 in which at least a part of two opposite hemispheres thereof is made conducting and forms electrodes 2, 3; a pulse generator 6; and an electric power supply source 4 which are located inside said body member **characterized in that** it additionally comprises an electrode 8 disposed on the body member 1 between said electrodes 2, 3 and means 7 for cyclically reversing polarity of pulses on said electrodes 2, 3, 8, wherein said additional electrode 8 is connected to one electrical lead of the pulse generator 6 whereas the electrodes 2, 3 are connected to another lead of the pulse generator 6, and electrostimulation efficiency of the device is independent upon opposite orientations of its body member within a given visceral organ.

8. An electrostimulator as claimed in claim 7 **characterized in that** said means 7 for cyclically reversing polarity of pulses on said electrodes 2, 3, 8 are made in the form of at least one pulse packet shaper 9 and a multiplexing switch 11 controlling said shaper.

9. An electrostimulator as claimed in claim 7 **characterized in that** said additional electrode 8 is made ring-shaped, transversely encompassing said olive-like or ovate-cylindrical body member 1.

10. An electrostimulator as claimed in claim 8 **characterized in that** said additional electrode 8 is made ring-shaped, transversely encompassing said olive-like or ovate-cylindrical body member 1.

11. An electrostimulator as claimed in claim 9 **characterized in that** said electrodes 2 , 3 on hemispheres of said olive-like or ovate-cylindrical body member 1 are provided equidistant from said additional electrode 8.

12. An electrostimulator as claimed in claim 10 **characterized in that** said electrodes 2, 3 on hemispheres of said olive-like or ovate-cylindrical body member 1 are provided equidistant from said additional electrode 8.

13. An electrostimulator as claimed in any of the preceding claims 1 - 12 **characterized in that** said electrodes 2, 3 on hemispheres of said olive-like or ovate-cylindrical body member 1 are provided identical.

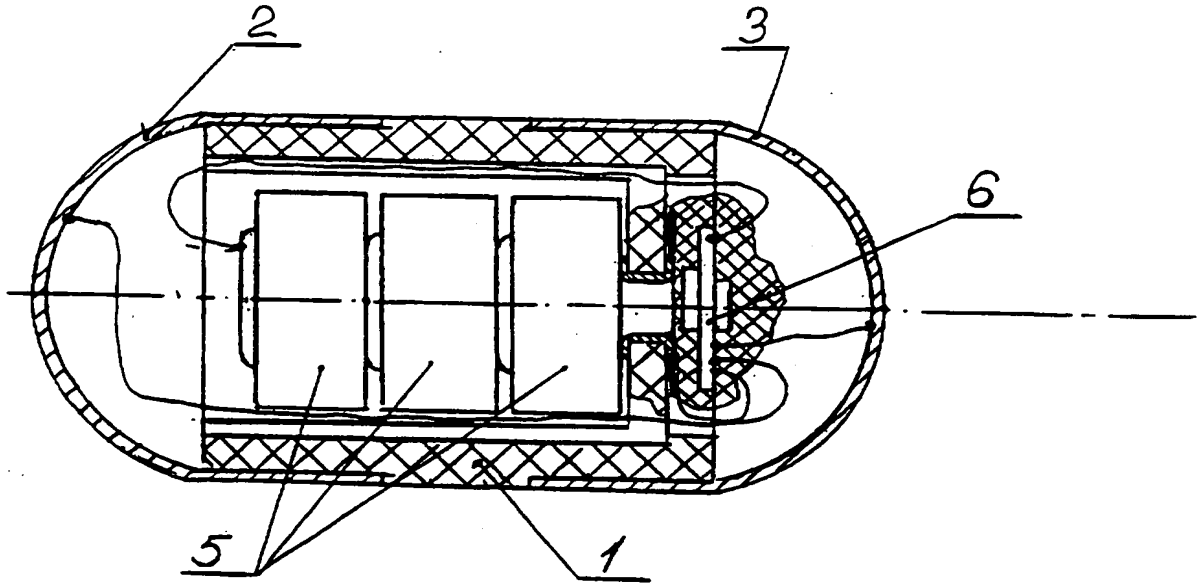

Fig. 1

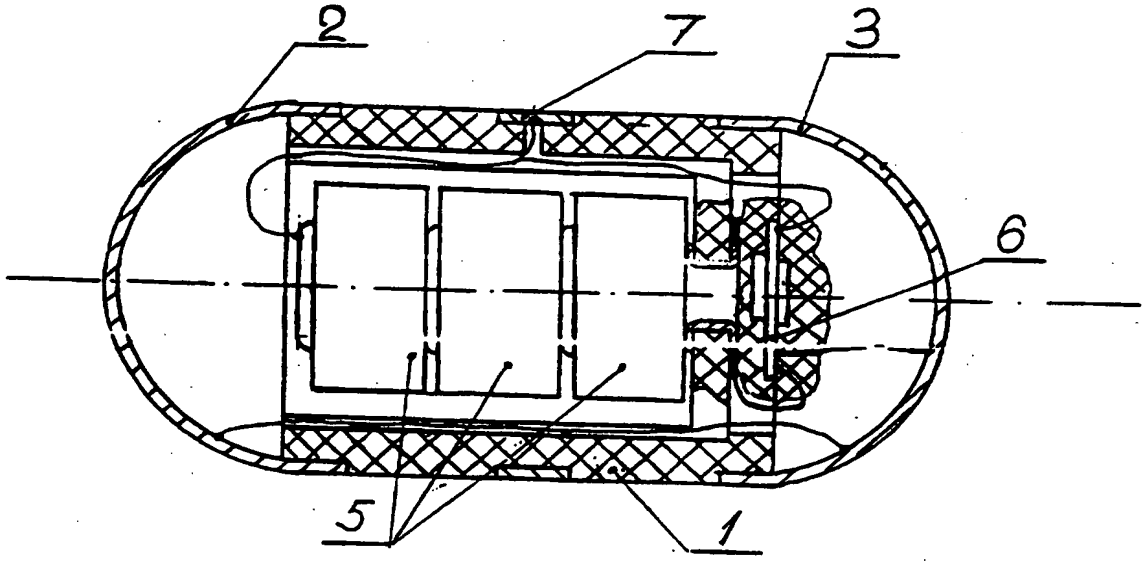

Fig. 3

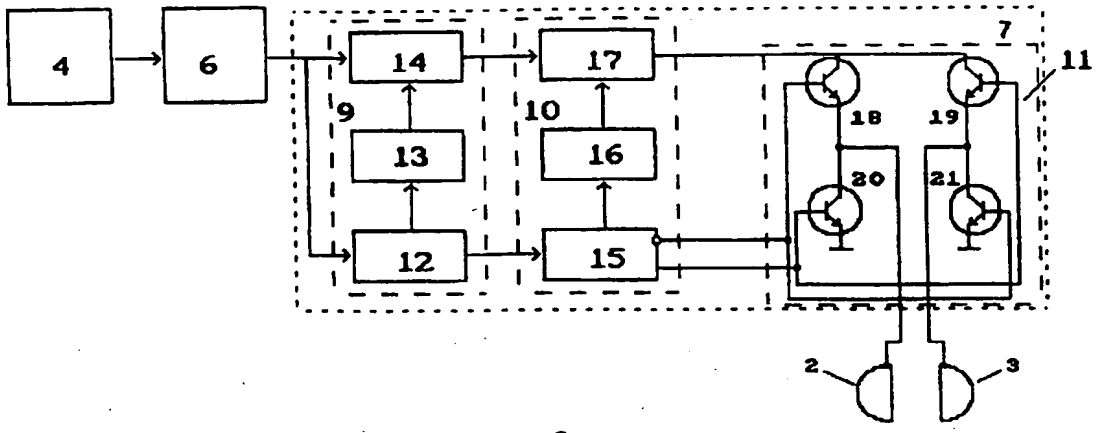

Fig. 2

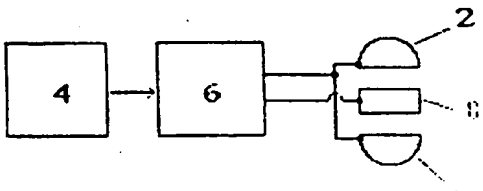

Fig. 4

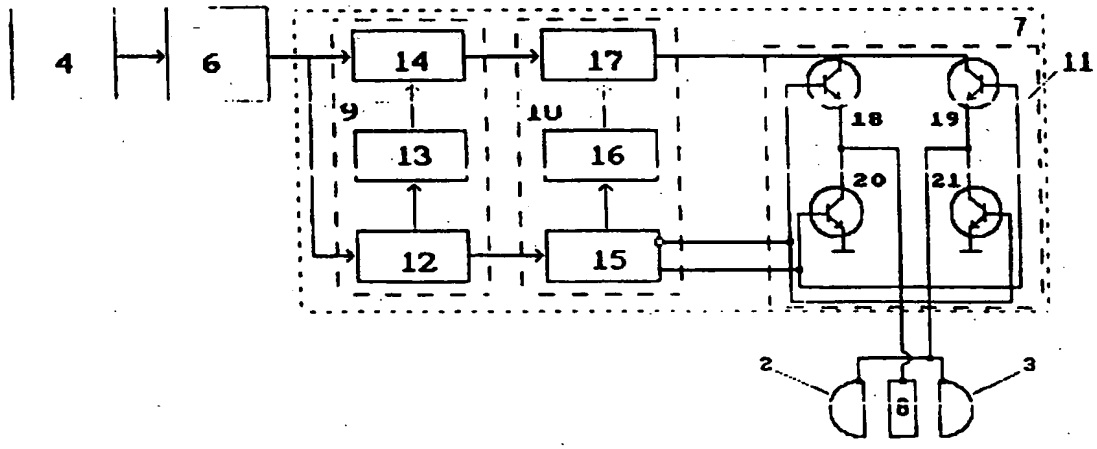

Fig. 5